Application of Biocompetitive Exclusion in Prevention and Controlling Biogenic H₂S of Petroleum Reservoirs

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Abstract: Usually, production of biogenic H₂S occurs in many of the petroleum reservoir that it causes the serious operational problem such as corrosion. By adding the extra inorganic nutrients, we can create a media for growth and development of other microorganisms in the reservoir. Denitrification Bacteria is activated by nitrate and nitrite injection. The growth and development of them have an important effect on SRB bacteria. In this study, we observed that the activity of SRB bacteria reduces severely and Denitrification Bacteria production occupies reservoir instead of SRB production.

Key word: Sulfate-reducing bacteria, Reservoir souring, Biocompetitive Exclusion, Microbial, Treatment.

INTRODUCTION

The presence of H₂S in the reservoir is the main problem in industry, and it creates harsh damage in subsurface and surface equipments. In some cases, it is a reason for abandonment of petroleum reservoirs (Cui, et al., 2004; ZoBell, 1957).

One of the reasons of reservoir souring is SRB activity. This produced H₂S is called biogenic H₂S which sulfate reduces to sulfide due to SRB anaerobic bacteria activity (Fitzgerald, et al., 1998).

Several methods for prevention and treatment the effects of biogenic H₂S exist such as corrosion inhibitors. Corrosion inhibitors remove and control the effect of iron corrosion and don’t have the ability to prevention the SRB activity (Cui, et al., 2004). Another method (biocide) is based on the inactivation of bacteria (Hitzman, et al., 1995).

The principle of biocide method is based on the remedial treatment and prevention of SRB growth. We must use them before SRB activity. Biocide is very active and there is the possibility of combining it with hydrocarbon and rock in the reservoir. We require more biocide that it is not economic.

Biocompetitive exclusion is a new technology based on Control of microbial growth. This method not only avoids the SRB activity in the reservoir but also in some cases it has a significant effect in enhance oil recovery (Ehler and Hall, 1982; Fitzgerald, et al., 1998; Reinsel, et al., 1996).

MATERIAL AND METHOD

Growth and activity of SRB are associated with access and availability of sulfate and carbon source in media. Recent studies showed that short chain VFA is the main carbon source for a microorganism. In other hands, presence of VFA is an evidence for ability microorganism activity in the reservoir. The ordinary VFA is acetic, propionic, and butyric acids. The reports showed that the concentration of VFA in the reservoir is high (MacGowan, et al., 1988).

Studies on produced fluids from petroleum fields showed that fluids contain enough nutrients to active and support the growth of a microorganism in the reservoir, especially SRB bacteria (Ehler and Hall, 1982). SRB requires sulfate and VFA as a carbon source for growth and activity. The equations below descript the SRB activity with VFA.

\[
1. \text{Acetate} + SO_4^{2-} = H_2O + CO_2 + HCO_3^- + S^{2-} \\
2. \text{Propionate} + 7SO_4^{2-} = 12H_2O + 12CO_2 + 7S^{2-} \\
3. \text{Butyrate} + 5SO_4^{2-} = 8H_2O + 8CO_2 + 5S^{2-}
\]
Other kinds of the microorganism in the reservoir can use VFA. So by controlling the using the VFA, we can limit and restrict the activity of SRB. By adding the inorganic nutrients, we can create a competition for using VFA that this is a unique approach for constricting the SRB activity.

Competitive bacteria such as anaerobic Thiobacillus and heterotrophic denitrifiers are already present in the reservoir adding extra bacteria are not necessary. By adding nitrate as an electron acceptor that is more active than sulfite. We can restrict SRB activity and reduce H₂S production. The production of BCX reaction is N₂ instead of H₂S. With injection of selected nutrient the beneficial bacteria can grow rapidly. These nutrients usually contain nitrate and nitrite. The injection of selected nutrient into the reservoir was caused enhancing the growth of beneficial bacteria and prevention of SRB bacteria (Ehler and Hall, 1982; Fitzgerald, et al., 1998; Reinsel, et al., 1996).

We investigated the reservoirs that have major problem with biogenetic H₂S between them a reservoir with the low production rate was selected for testing the efficiency of biocompetetitive exclusion. Before the injection of nutrient, water of the reservoir was tested. The test was performed under the anaerobic condition for measurement the amount of H₂S, Sulfate and VFA and also kind of SRB and others anaerobic bacteria. Based on results, treatment program was designed. After the first injection, Production from the wells was stopped. The amount of H₂S was measured and injection program was corrected.

RESULTS AND DISCUSSION

A gas reservoir selected for treatment. The amount of H₂S was reported in a range between 700 – 950 ppm. Desulfovibrio desulfuricans is the main species of bacteria in the reservoir (Figure 1).

![Fig. 1: Percentage of SRB bacteria species in culture.](image1)

![Fig. 2: Effects of nitrate injection on H₂S.](image2)

In the beginning, water and H₂S were analyzed and a plan was designed for treatment. A 56 gallon of dilute nitrate injected to the well and well was closed for 5 days. The response of the reservoir was measured by H₂S monitoring and sulfide gradually decreases to 300 ppm (Figure 2). A periodic injection was performed in every 15 days. On August 20, the nutrient formulation of was updated to the mixing of nitrite and nitrite. The reservoir was treated with one gallon of new formulation every week. The likable and positive response was observed in fourth week of second series of injections (Figure 3). The sulfide in the reservoir dropped to near zero on
October. For detection the reservoir stability, the injection was stopped and an increase of H$_2$S detected after one month (Figure 4). The results of experiment were showed in figure 5.

**Fig. 3:** Effects of nitrate and nitrite injection on H$_2$S.

**Fig. 4:** Reservoir stability after stopping the injection.

**Fig. 5:** Results of Biocompetitive exclusion experiment.
Conclusion:
Biocompetitive exclusion is a new technology that has demonstrated its potential in reservoir souring treatment. The method is based on the biotreatment and has more efficiency than old method like biocide and scavenger without environmental pollution. In other hands, BCX is an economical and practical method for prevention of biogenic H_2S production.

REFERENCES